Posterior lumbar interbody fusion versus posterolateral fusion in spondylolisthesis: a prospective controlled study in the Han nationality

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Abstract In this prospective study, our aim was to compare the clinical outcome of posterior lumbar interbody fusion (PLIF) and posterolateral fusion (PLF) in spondylolisthesis. A total of 138 patients with spondylolisthesis were randomly assigned to two groups: those operated on with pedicle screw fixation and posterior lumbar interbody fusion by autografting (PLIF), and those operated on with pedicle screw fixation and posterolateral fusion by autografting (PLF). The patients were followed-up for four years. Clinical evaluation was carried out using the Oswestry disability index (ODI) and pain index (VAS). Radiography was performed preoperatively and postoperatively to assess the fusion. Both surgical procedures were effective, but the PLF group showed more complications related to hardware biomechanics. There was no significant statistical difference in clinical and functional outcome in the two groups. The PLIF group presented a better fusion rate than the PLF group.

Résumé Le but de cette étude prospective est de comparer les résultats et le devenir clinique de l'arthrodèse intercorporelle (PLIF) et des arthrodèses postérolatérales (PLF) dans le spondylolisthésis. 138 patients présentant un spondylolisthésis ont été randomisés en deux groupes: les opérés par fixation avec vis pédiculaires et fusion intercorporelle par voie postérieure et autogreffe (PLIF), et les a été opérés toujours par fixation pédiculaire mais avec greffes postéro-latérales (toujours par autogreffes) (PLF). Les patients ont été suivis pendant 4 ans. L'évaluation clinique

a été réalisée à l'aide de l'index d'Oswestry (ODI) et la douleur à l'aide de l'échelle visuelle analogique. Les radiographies ont été réalisées en pré et post-opératoire de façon à évaluer la fusion. Ces deux procédés sont efficaces néanmoins, pour le groupe PLF, on déplore plus de complications relatives au matériel. Il n'y a pas de différences significatives sur le devenir clinique et fonctionnel dans les deux groupes, le groupe PLIF présentant un meilleur taux de fusion comparé au groupe PLF.

Introduction

Spondylolisthesis is the subluxation of a vertebral body over another in the sagittal plane. Surgery is indicated if symptoms are disabling and interfere with work, if the condition is progressive, or if there is a significant neurological deficit. The ideal surgical treatment remains controversial [6]. From theoretical considerations, posterior lumbar interbody fusion (PLIF) has been considered better than posterolateral fusion (PLF). Theoretical advantages in favour of PLIF include anterior column support, indirect foraminal decompression, restoration of lordosis, and maintenance of intervertebral disc height. Suk et al. [12] used bone grafts as intersomatic spacers and pedicular fixation in the treatment of isthmic spondylolisthesis to provide a truly circumferential fusion with good results.

Due to the complications of impacted bone grafts collapsing into the disc space, we have used polyether-etherketone (PEEK) cages as intersomatic spacers. We have found few papers in the literature comparing the use of pedicle screws with pedicle screws associated with a posterior intersomatic posterior fusion in the surgical management of lumbar spondylolisthesis [10, 13].

The purpose of this study was to compare efficacy of the posterior lumbar interbody fusion (PLIF) with the posterior

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lumbar fusion (PLF) in adult spondylolisthesis in the Han nationality in China and to compare the fusion rate of both procedures.

Materials and methods

Between January 2001 and May 2003, a total of 138 patients with spondylolisthesis were randomly assigned to two groups. Seventy patients were operated on with pedicle screw fixation and posterior lumbar interbody fusion by autografting (PLIF) and 68 were operated on with pedicle screw fixation and posterolateral fusion by autografting (PLF). PEEK cages (Stryker, USA) were used in the PLIF group, and all of the patients were operated on by the same surgeon.

The inclusion criteria were spondylolisthesis (isthmic or degenerative), no past history of spine surgery, age between 18 and 60, and low back pain with or without sciatica. Exclusion criteria were infection and drug or alcohol abuse.

All patients signed an informed consent form and the study was approved the Ethics Committee of Qilu Hospital of Shandong University, Jinan, China.

In this series, 66 patients were female (47.8%) and 72 were male (52.2%). In the PLIF group, mean age was 49 years (range, 36–62), and in the PLF group, mean age was 48 years (range, 38–63).

Sixty-four patients had spondylolisthesis at the L4–5 level and another 78 at the L5–S1 level. There were 56 cases of degenerative spondylolisthesis (40.6%) and 82 cases of isthmic spondylolisthesis (59.4%). Spondylolisthesis was classified as grade I in 62 cases (44.9%) and grade II in 76 cases (55.1%).

Clinical symptoms and signs included low-back pain in 126 cases (91.3%), radicular pain in 123 patients (89.1%), neurogenic claudication in 68 patients (49.2%), and neurological deficits were observed in 69 cases (50.0%).

Plain radiographic studies of the lumbar spine included anteroposterior, oblique, and lateral views, and whenever possible, supine-standing and flexion–extension were also obtained. CT and MRI were encouraged for all patients.

Operative techniques in the PLIF group were such that patients were carefully positioned in the prone position, and one skin incision about 11 cm in length was made in the midline. After complete bony exposure a postero–lateral decompression of the neural elements was performed with laminectomy, medial facetectomy, and foraminotomy. Complete discectomy was performed following which the disc space was sequentially distracted. Cages (PEEK cage, Stryker) were inserted into the disc space, and autologous bone graft from the excised loose lamina and spinous

process was placed anterior to the cages. After placement of the interbody cages and autologous bone graft, pedicle screw-rod instrumentation was performed in the conventional technique.

In the PLF group, patients were carefully positioned in the prone position. One skin incision about 11 cm in length was made on the midline. After complete bony exposure decompression was performed. By definition, the nerve root release procedure was the same in both groups. Pedicle screw-rod instrumentation was performed in the conventional technique, and autologous bone graft harvested from iliac bone was placed posterolaterally.

A brace was necessary for walking during the first postoperative month. Progressive rehabilitative therapy was administered in both groups.

All patients completed a questionnaire on functional disability, pain, and work status before treatment and at one and four years at outpatient visits. The four-year follow-up visits were conducted by an unbiased observer. The follow-up rate was 95.7% (67/70) in the PLIF group and 95.6% (65/68) in the PLF group.

Assessment of results for pain index was measured postoperatively and at three months, one year, and four years of follow-up. Pain index was the mean of two visual analogue scale (VAS) scores for “pain right now” and “worst pain last week.” Functional disability was measured by the Oswestry disability index (ODI) [7].

The ODI is a validated disease-specific instrument for assessment of spinal disorders consisting of a ten-item ordinal scale instrument with six response alternatives for each item. The total score ranges from 0 to 100, where 100 is the worst disability. The items are pain intensity, personal care, ability to lift, walk, sit, stand, sleep, sex life, social, and travelling. For each item, normal function is 0 and worst is 5. The sum of the ten “items” multiplied by two constitutes the ODI (0–100).

Global outcome was assessed by the patient at four-year follow-up as “much better,” “better,” “unchanged,” or “worse.”

For the radiographic comparison of both groups, anteroposterior and lateral view lumbar radiographs were obtained postoperatively and at three months, one year, and four years of follow-up. Solid fusion was determined at the six-month follow-up using the criteria described by Park and Ha [15].

Statistical evaluation of the ODI and pain index (VAS) was carried out with the Mann-Whitney U-test. Global outcome was analysed by the Pearson chi-square test, and the Fisher test was used to evaluate the fusion rates. The 0.05 value was used to define statistical significance. Computations were performed with the use of SAS software (SAS Institute Inc., Cary, NC, USA).

Results

The distribution of age, sex, level, and disability were similar in both groups (Table 1). The mean operating time was 3.5 hours for PLIF patients and 3.2 hours for PLF.

The pain index improved significantly from before surgery to four-year follow-up in both groups. In the PLIF group the pain index improved from 68 to 26 ($P<0.001$). In the PLF group the pain index improved from 67 to 29 ($P<0.001$), but there was no significant statistical difference between the two groups ($P=0.81$). In the PLIF group preoperative mean Oswestry score was 31.3 (16–80), and postoperative 14.1 (0–28). In the PLF group, Oswestry mean preoperative and postoperative scores were 30.8 (18–78) and 16.1(0–30), respectively. There was no significant statistical difference in the overall results of the Oswestry scores ($P=0.41$). The global outcome was similar in both groups (Table 2).

Complications included CSF leak in one patient in the PLF group, and there was one patient with a deep vein thrombosis in the PLF group. There was one patient with deep wound infection in the PLIF group.

Radiographic results found that solid fusion was achieved in 63 of 68 (92.6%) in the PLIF group (Figs. 1 and 2). Solid fusion was achieved in 53 of 66 (80.3%) in the PLF group. The PLF group patients presented a higher complication rate with three screw fractures and two occurrences of loosening of the metalwork. One patient had persistent back and leg pain. No such complications occurred in the PLIF group. This difference was statistically significant ($P=0.0258$). Nonunion rates at the last follow-up in the two fusion groups were statistically significant, with 7.4% in the PLIF group and 19.7% in the PLF group ($P=0.036$).

Discussion

Spondylolisthesis is a common cause of segmental instability. For a long time, posterolateral fusion with pedicle

screw fixation was the most popular procedure for arthrodesis. In spondylolisthesis patients, concern for spinal biomechanics is key to proper surgical management. This is in accordance with the literature. Intersomatic lumbar spacers along with posterior fusion are used for the purpose of improving fusion and spinal biomechanics, and to provide better support for the anterior spinal column [1, 12]. Crawford et al. [3] reproduced the lumbar spondylolisthesis grade I using cadaveric specimens and studied the biomechanics of various hardware combinations including cages with and without intersomatic spacers, pedicle screws alone, and pedicle screws with cages. Pedicle screws with cages presented better biomechanics in flexion, lateral extension, axial rotation, and shear forces. In specimens with cages, there was instability and fatigue. The authors suggest the use of screw systems and cages in grade I lumbar spondylolisthesis patients because the greater stability may allow for good fusion around the cages.

The use of interbody fusion with a cage offers several theoretical advantages: restoration of load-bearing capacity to the ventral spinal column, maintenance of intervertebral disc height, distraction of intervertebral foramina, immediate stabilisation, and higher repeatability of the surgical technique. A series of biomechanical tests and clinical studies of interbody fusion cages were published with impressive biomechanical advantages and clinical safety [5].

Many believe that interbody fusion (fusion between the vertebral bodies) offers a number of advantages to posterior interlaminar or posterolateral intertransverse process fusion. The cancellous bone of the vertebral body provides an excellent fusion bed, as opposed to the surgically traumatised posterior paraspinal musculature. Interbody fusion allows the disc to be both space evacuated and distracted. Distraction allows the neural foramen to be enlarged, eliminating any foraminal stenosis that might be present secondary to degenerative loss of disc height.

In spinal fusion, preparation of the fusion site and handling of the tissue bed are vital to ensure a successful arthrodesis. In general, the larger the surface area decorti-

Table 1 Demographics, level, and lifestyle factors for each type of treatment

	PLIF group	PLF group	Value
Mean age (y)	49	48	0.33
Male	55.7% (39/70)	52.9% (36/68)	0.74
L4–5 level	72.9% (51/70)	76.4% (52/68)	0.63
L5–S1 level	27.1% (19/70)	23.5% (16/68)	0.23
Degenerative spondylolisthesis	58.6% (41/70)	60.3% (41/68)	0.83
Isthmic spondylolisthesis	47.1% (33/70)	42.6% (29/68)	0.61
Smokers	25.7% (18/70)	22.1% (15/68)	0.43
Pain index	68	67	0.56
ODI	31.3	30.8	

The p value refers to the comparison between the PLIF and PLF

Table 2 Global outcome between the two groups at four-year follow-up*

	PLIF group	PLF group
Much better	53.7 (36/67)	50.7 (33/65)
Better	38.8 (26/67)	36.9 (24/65)
Unchanged	6.1 (4/67)	9.3 (6/65)
Worse	1.4 (1/67)	3.1 (2/65)

* There was no significant statistical difference between the two groups ($P=0.61$)

cated for fusion, the greater the contact area exposed to support a spinal fusion. PLIF can offer a larger surface area for fusion than PLF. In our study, the fusion rate in the PLIF group was better than in the PLF group. In the PLF group, all patients had iliac crest bone graft. In the PLIF group the source of the bone graft is laminar and spinous process. Although the PLIF group received larger volumes of bone graft, it cannot be excluded that the grafting material was of slightly worse quality in the PLIF group compared with the PLF group [13]. For these reasons, the

Fig. 1 Lateral view of L_{4/5} spondylolisthesis preoperative **Fig. 2** Lateral view of L_{4/5} spondylolisthesis operated on with PLIF with a PEEK cage. Solid fusion at four-year follow-up

difference in grafting technique most likely did not affect outcome. Kornblum et al. [8] found the pseudoarthrosis rate influenced the final results and the use of instrumentation with pedicle screws in patients submitted to fusion. We also found that if posterior pedicle fixation was used in combination with an interbody fusion cage, the incidence of cage subsidence was significantly lowered and the fusion rate increased. This result was consistent with the clinical studies of Brantigan et al. [2] and William et al. [14].

Some authors consider the PLIF procedure difficult due to the increased bleeding, prolonged operation time, and more extensive dissection [6]. But in our series, no patient in the PLIF group presented complications related to hardware biomechanics. Five patients in the PLF group presented complications: three screw fractures and two loosening of the implants, with one patients requiring reoperation. There was significant statistical difference in the complication rate of the PLF group compared to the PLIF group ($P=0.0258$).

The literature shows concerns with quality of life in spondylolisthesis patients. Madan and Boeree [10] used the Oswestry questionnaire, among other tools, to evaluate the

final outcomes of patients with lumbar spondylolisthesis submitted to a posterior fusion procedure or a PLIF procedure. An Oswestry index of 69% was reported in the PLF group and 81% in the PLIF group. PLIF patients retained correction and presented better fusion rates. Our study shows Oswestry index of 89% with good or excellent results in the PLIF patients, and 86% in PLF patients. The difference was not statistically significant.

In a recent prospective randomised study on degenerative lumbar disease, Kim et al. [9] compared three fusion methods: posterolateral fusion (PLF), posterior lumbar interbody fusion (PLIF), and PLIF combined with PLF (PLF+PLIF), and reported that no significant differences in clinical results and union rates were found among the three methods. PLIF had better sagittal balance than PLF. The study by Butt and Dhar also suggested that clinical outcome is closely related to the attainment of solid fusion in isthmic spondylolisthesis [11].

Dantas et al. [4] conducted a study of 60 adult lumbar spondylolisthesis patients. The patients were divided into two groups. Group I comprised the first 30 consecutive patients that were submitted to a posterior lumbar spinal fusion with pedicle screws (PLF). Group II comprised the last 30 consecutive patients submitted to a posterior lumbar interbody fusion procedure (PLIF) with pedicle screws. The mean follow-up was 3.2 years. They concluded that both surgical procedures were effective. The PLIF with pedicle screws group presented better clinical outcomes. PLF presented more complications when compared with PLIF. PLIF presented better results as indicated in the Prolo economic and functional scale. The results of our study were similar to the findings of Dantas.

In conclusion, based on our series we conclude that if there is instability affecting the three-column spine in spondylolisthesis, posterior interbody fusion with pedicle screws (PLIF) provides a more solid mechanical construction when compared with the pedicle screws used alone. Both surgical procedures were effective, although the PLF group showed more complications related to hardware biomechanics. Clinical and functional outcomes in both groups were similar, and no significant statistical difference was found. But PLIF presented better fusion rate when compared with PLF.

References

1. Brantigan JW, Neidre A (2003) Achievement of normal sagittal plane alignment using a wedged carbon fiber reinforced polymer fusion cage in treatment of spondylolisthesis. *Spine* 22:210–220
2. Brantigan JW, Steffee DA, Lewis ML et al (2000) Lumbar interbody fusion using the Bratigan I/F cage for posterior lumbar interbody fusion and the variable pedicle screw placement system. *Spine* 25:1437–1446
3. Crawford S, Çagli S, Sontag VKH (2001) Biomechanics of grade I degenerative lumbar spondylolisthesis: part 1. In vitro model. *J Neurosurg* 94(1):45–50
4. Dantas FL, Prandini MN, Ferreira MA (2007) Comparison between posterior lumbar fusion with pedicle screws and posterior lumbar interbody fusion with pedicle screws in adult spondylolisthesis. *Arq Neuropsiquiatr* 65:764–770
5. Dijk MV, Smit TH, Sugihara S et al (2002) The effect of cage stiffness on the rate of lumbar interbody fusion: an in vivo model using poly (l-lactic acid) and titanium cage. *Spine* 27:682–688
6. Dai LY, Jia LS, Yuan W et al (2001) Direct repair of defect in lumbar spondylolysis and mild isthmic spondylolisthesis by bone grafting, with or without joint fusion. *Eur Spine J* 10:78–83
7. Fairbank JC, Pynsent PB (2000) The Oswestry disability index. *Spine* 25:2940–2952
8. Kornblum MB, Fischgrund JS, Herkowitz HN (2000) Degenerative lumbar spondylolisthesis with spinal stenosis: a prospective long-term study comparing fusion and pseudoarthrosis. Presented at the American Academy of Orthopedic Surgeons annual meeting, Orlando, FL, 15–19 March
9. Kim KT, Lee SH, Lee YH et al (2006) Clinical outcomes of 3 fusion methods through the posterior approach in the lumbar spine. *Spina* 31:1351–1358
10. Madan S, Boeree NR (2002) Outcome of posterior lumbar interbody fusions versus posterolateral fusion for spondylolisthesis. *Spine* 27:1536–1542
11. Butt MF, Dhar SA (2007) In situ instrumented posterolateral fusion without decompression in symptomatic low-grade isthmic spondylolisthesis in adults. *Int Orthop*. DOI [10.1007/s00264-007-0367-0](https://doi.org/10.1007/s00264-007-0367-0)
12. Suk S, Lee CK, Kim W, Lee J, Cho K (1997) Adding posterior lumbar interbody fusion to pedicle screw fixation and posterior fusion after decompression in spondylolytic spondylolisthesis. *Spine* 22:210–220
13. Kho VK-S, Chen W-C (2008) Posterolateral fusion using laminectomy bone chips in the treatment of lumbar spondylolisthesis. *Int Orthop* 32:1115–1119
14. William LTC, Brett CPT, Aman CPT et al (2001) Lumbar sagittal contour after posterior interbody fusion: treaded devices alone versus vertical cages plus posterior instrumentation. *Spine* 26:534–537
15. Park Y, Ha JW (2007) Comparison of one-level posterior lumbar interbody fusion performed with a minimally invasive approach or a traditional open approach. *Spine* 32:537–543